Scientific Papers. Series D. Animal Science. Vol. LXI, Number 1, 2018
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

THE ROLE OF COMMERCIALLY PRODUCED BUMBLEBEES IN GOOD AGRICULTURAL PRACTICES

Ayhan GOSTERIT[1], Fehmi GUREL[2]

[1]Department of Animal Science, Faculty of Agriculture, SüleymanDemirel University, Isparta, Turkey
[2]Department of Animal Science, Faculty of Agriculture, Akdeniz University, Antalya, Turkey

Corresponding author email: ayhangosterit@sdu.edu.tr

Abstract

Insufficient pollination due to low temperatures, high humidity, low light intensity and isolated atmosphere is one of the major problems in greenhouse vegetable production. These unsuitable conditions cause to insufficient production of fertile pollen, low pollen dynamism and finally serious pollination problems in greenhouses. Before 1990s, plant growth regulators which are also called as hormone spray were frequently used for greenhouse crop pollination. However, there is a worldwide interest to use the bumblebees as a pollinator of many crops in recent years. Due to their excellent pollinator behavior, bumblebees are indispensable element for especially greenhouse tomato production. Using of bumblebee also contribute to necessity of Good Agricultural Practices such as environmental sustainability, economic viability, social acceptability and food safety and quality. In this experiment, we aimed to evaluate the importance of commercially produced bumblebees in terms of environment friendly agriculture.

Key words*: bumblebee, crop pollination, food safety, good agricultural practices.*

INTRODUCTION

The industrialization of agriculture and development of synthetic chemicals have allowed growers to increase yields. Traditionally crop protection in greenhouse horticulture has also been based on the use of pesticides. In the early 1980s, growing concern for the human health and environment has led to try to find some alternatives to chemicals (Yılmaz et al., 2002; van der Velden et al., 2012). The concept of Good Agricultural Practices (GAP) has evolved in the context of a rapidly changing and globalizing food economy and as a result of the concerns and commitments of a wide range of stakeholders about food production and security, food safety and quality, and the environmental sustainability of agriculture. Good Agricultural Practices (GAP) are practices that address environmental, economic and social sustainability for on-farm processes and result in safe and quality food and non-food agricultural products (Ersoy et al., 2017; FAO, 2003). The use of bumblebee colonies to pollinate greenhouse crops is more effective than mechanical vibration or plant growth regulators (Dasgan et al., 2004). They have also led to improved integrated pest management (IPM) practices, resulting in a large reduction in the use of pesticides and other spray chemicals. Therefore the use of bumblebees for greenhouse pollination helps improve the safety and quality of greenhouse products and seems to be one of the Good Agricultural Practices. Evaluation of importance of commercially produced bumblebees in terms of Good Agricultural Practices was aimed in this review.

MATERIALS AND METHODS

Papers that examined the importance, year round rearing processes, pollination effectiveness and invasive potential of bumblebees were reviewed. The history of commercial rearing, use of these bees in greenhouse, their effects on fruit quality and quantity, and possible effects of bumblebee commercialization on ecology were explained.

RESULTS AND DISCUSSIONS

The history of commercial bumblebee rearing

The history of bumblebee research related to domestication and the importance of bumblebees as pollinating insects in agriculture have a long history that is over a hundred years

old (Sladen, 1912). But, after understanding the importance of bumblebees in greenhouse production, the year round rearing of bumblebees was achieved in the Netherlands and Belgium due to the efforts of commercial companies approximately 30 years ago. Since then, commercially reared bumblebee colonies have been used on a large scale for greenhouse pollination and demand for the bees by growers has been very high. Therefore, the number of colonies used is being increased rapidly year by year. In 2004, the total number of colonies of all species and on all continents sold was estimated to be around one million (Velthuis and van Doorn, 2006). Commercially reared colonies have been used in many countries, including some outside of its native range (Kraus et al., 2011). Although, commercial companies have not shared any production data we estimated that current worldwide sales of commercial bumblebee colonies has reached some three million colonies. For example, in Turkey, the number of colonies used as pollinators of greenhouse crops have increased rapidly year by year and reached to about 250,000 colonies yearly in 2017.

This high demand worldwide also caused to increase of interest for commercial rearing of bumblebees. However, lack of knowledge and inexperience about mass and commercial rearing of bumblebee can be important risks for new investors. The most important step is to have the technical knowledge and experience for commercial rearing. Additionally, the producers should have convenient rearing laboratory, required materials and equipments, hibernated queens for starting the rearing activity, official authorization for production and marketing, production planning according to sales forecast, healthy and quality queen rearing for sustainable production and experienced marketing staff for success in commercial rearing (Gosterit and Gurel, 2014).

Currently, about 250 species of true bumblebees have been identified (Williams, 1998). *Bombus terrestris* is the most commonly commercially reared species. This species is also one of the most abundant and widespread bumblebees throughout continental Europe and many Mediterranean and Atlantic islands (Chittka et al., 2004). *B. terrestris* includes nine subspecies (Rasmont et al., 2008). Although many of them were used in the early years of commercial rearing, *B. t. dalmatinus* proved to have superior characteristics in terms of mass rearing (Velthuis and van Doorn, 2006).

Colony foundation from queens, obtaining of young queens and males from colonies, mating of queens and males, and diapause control are main stages in commercially rearing of bumblebees. Colony supplier or breeders which have their own rearing process follow the natural life cycle of bumblebees and realize these stage in controlled conditions. Success of these stages directly affects the sustainability of mass rearing.

Bumblebee pollinatıon in greenhouses

The greenhouse industry is a very important segment of agriculture. One of the major problems in greenhouse vegetable production during winter is insufficient pollination due to low temperatures, low light intensity and isolated atmosphere. Insufficient production of fertile pollen and low pollen dynamism cause serious pollination problems in greenhouses. Studies have shown that a lack of pollination can significantly reduce fruit yield in greenhouse tomatoes and sweet peppers, especially early in the growing cycle (Abak et al., 1997). In recent years, a worldwide trend has been to use the bumblebees as a pollinator of many crops, including tomatoes, due to yield increase and enhancement of fruit quality. Bumblebees which work very long hours, forage from dawn to dusk even on cold, rainy or foggy days and are therefore very efficient pollinators. Bumblebee pollination has a positive effect on the yield, fruit weight, fruit volume and the number of seeds in fruits (Banda and Paxton, 1991).

Effects of bumblebee pollination in greenhouses were examined by different researchers for different crops. According to some previous reports, bumblebee pollination decreases the need for manual pollination, increases yield and quality of the greenhouse tomato crops (Ahmad et al., 2017), helps to produce more well-shaped fruit and the total marketable fruit production on greenhouse strawberry (Dimou et al., 2008), increases the fruit yield, fruit quality, and seed set of the pepper (Ercan and Onus, 2003).

Currently, bumblebees which are indispensable pollinator for especially greenhouse tomato completely replaced by mechanical vibration and plant growth regulators. They have some advantages as pollination agency: they pollinate the flowers through a method called "buzz pollination", a rapid vibrating motion which releases large amounts of pollen onto the bee; they have not sophisticated communication system of honeybees, therefore, in greenhouses: they are less likely to leave your crop for more attractive flowers; unlike honeybees, bumblebees are attracted to flowers with narrow corolla tubes, such as blueberries and cranberries; they mainly forage for pollen rather than nectar, and transfer more pollen to the pistils with each visit; they visit many more blooms per minute than honeybees; and they are much less aggressive than honeybees (Morandin et al., 2001; Dasgan et al., 2004; Velthuis and van Doorn, 2006; Ahmad et al., 2015). The use of bumblebee for pollination agency also indirectly contribute to decreasing of pesticide use.

Commercial bumblebee colonies can be easily purchased by all growers throughout the year. A commercial bumblebee colony which in small cardboard box should include a healthy queen, 60 to 70 worker bees and large brood area. Males and young queens have not begun to produce. The price of the colonies depends on the country or commercial firm. The number of colonies required per surface unit depends on the crop, variety, season, plant density, and type of glasshouse or tunnel. One colony can pollinate 1500-2000 m^2 of tomatoes for about 40 days, effectively. At the end of this period, colony life ends and colony is replaced with a new one.

Impact of commercially produced bumblebee colonies on ecosystem

Bumblebees are an important pollinator of wild flora as well as agricultural crops and are increasingly used as an effective commercial pollinator in greenhouses crops mainly in tomatoes all over the world. Although five species of bumblebees are reared commercially on a large scale, the Eurasian *B.terrestris* L. is the most reared subspecies for commercial pollination and has been used outside its natural distribution area. Very early after commercial introduction, it was recognized that this species is invasive and may disturb local ecosystems (Goulson, 2003). There are many invasive characteristics of *B. terrestris* such as high migration ability, early seasonal emergence, high adaptability under adverse climatic conditions in various habitat, polylectic foraging strategies and regulation of life cycle in a year in newly colonized area (Dafni et al., 2010). It is known that, commercial *B. terrestris* colonies produce more queens than local populations. A single *B. terrestris* colony may produce more than a hundred of new queens which may escape from greenhouses and found nest in native flora (Gosterit and Baskar, 2016). The invasion and the increase in population of introduced *B. terrestris* in the new areas have caused some problems, such as competition with native pollinators for floral resources and nest sites, the introduction of parasites and pathogens, and hybridization with native species. Therefore their potentially effects on the environment are also being observed carefully (Goka et al., 2001). It should not be forgotten that *B. terrestris* has colonized the native ecosystems of some countries where it does not occur naturally, including Japan, New Zealand, Tasmania, Chile and Israel as a result of commercial introductions (Macfarlane and Gurr., 1995; Ruz and Herrera, 2001; Hingston et al., 2002; Inoue et al., 2008; Dafni et al., 2010).

CONCLUSIONS

Bumblebees are excellent pollinators of tomatoes, peppers, eggplants and other crops grown in greenhouses. Bumblebee pollination increases the yield and the quality of the fruits and reduces the need for insecticide application. Therefore, we recommend the using of commercial bumblebee colonies in greenhouses as one of the Good Agricultural Practices. On the other hand, its spreading speed, adaptation to different conditions, hybridization with native species, competition with native pollinators for resources and potential for pathogen spillover need to be taken into consideration. While the use of bumblebees is recommended, some regulations also must be made such as using covering nets, killing colonies and then burning the hive after

use, using queen excluder and using colonies with health certificate to prevent escaping of *B. terrestris* from greenhouses and decrease their negative ecological impacts.

REFERENCES

Ahmad M., Bodlah I., Mehmood K., Sheikh U.A.A., Aziz M.A., 2015. Pollination and foraging potential of european bumblebee, *Bombus terrestris* (Hymenoptera: Apidae) on tomato crop under greenhouse system. Pakistan Journal of Zoology, 47, 1279-1285.

Abak K., Dasgan H.Y., Ikiz O., Uygun N., Kaftanoğlu O., Yeninar H., 1997. Pollen production and quality in pepper grown in unheated greenhouses during winter and the effects of bumblebee pollination on fruit yield and quality. Acta Horticulturae, 437, 303-307.

Banda H.J., Paxton R.J., 1991. Pollination of greenhouse tomatoes by bees. Acta Horticulturae, 288, 194-197.

Chittka L., Ings T.C, Raine N.E., 2004. Chance and adaptation in the evolution of island bumblebee behaviour. Population Ecology, 46, 243–251.

Dafni A., Kevan P., Gross C.L., Goka K., 2010. *Bombus terrestris*, pollinator, invasive, and pest: An assessment of problems associated with its widespread introductions for commercial purposes. Applied Entomology and Zoology, 45(1), 101–113.

Dasgan H.Y., Özdoğan A.O., Kaftanoğlu O., Abak K., 2004. Effectiveness of bumblebee pollination in anti-frost heated tomato greenhouses in the Mediterranean Basin. Turkish Journal of Agriculture and Forestry, 28, 73-82.

Dimou M., Taraza S., Thrasyvoulou A., Vasilakakis M., 2008. Effect of bumblebee pollination on greenhouse strawberry production. Journal of Apicultural Research and Bee World, 47(2), 99-101.

Ercan N., Onus A.N. 2003. The effects of bumblebees (*Bombus terrestris* L.) on fruit quality and yield of pepper (*Capsicum annuum* L.) grown in an unheated greenhouse. Israel Journal of Plant Sciences, 51(4), 275-283.

Ersoy N., Yilmaz S., Gumus E., 2017. The importance of good agricultural practices in EU membership process. Mediterranean Agricultural Sciences, 30(2), 133–136.

FAO., 2003. Development of a framework for Good Agricultural Practices. FAO, Committee on Agriculture, Seventeen Session, 31 March-4 April, Roma, 35p.

Goka K., Okabe K., Yoneda M., Nivas S., 2001. Bumblebee commercialization will cause worldwide migration of parasitic mites. Molecular Ecology, 10, 2095-2099.

Gosterit A., Gurel F., 2014. Basic necessities for commercial rearing of bumblebee, *Bombus terrestris* L. Süleyman Demirel University Journal of the Faculty of Agriculture, 9(2), 102-111.

Gosterit A., Baskar V.C., 2016. Impacts of commercialization on the developmental characteristics of native *Bombus terrestris* (L.) colonies. Insectes Sociaux, 63(4), 609-614.

Goulson D., 2003. Effects of introduced bees on native ecosystems. Annual Review of Ecology Evolution and Systematics, 34, 1–26.

Hingston A., Marsden-Smedley J., Driscoll D., Corbett S., Fenton J., Anderson R., Plowman C., Mowling F., Jenkin M., Matsui K., Bonham K., Ilowski M., McQuillan P., Yaxley B., Reid T., Storey D., Poole L., Mallick S., Fitzgerald N., Kirkpatrick J., Febey J., Harwood A., Michaels K., Russell M., Black P., Emmerson L., Visoiu M., Morgan J., Breen S., Gates S., Bantich M., Desmarchelier J., 2002. Extent of invasion of Tasmanian native vegetation by the exotic bumblebee *Bombus terrestris* (Apoidea: Apidae). Austral Ecology, 27, 162–172.

Inoue M.N., Yokoyama J., Washitani I., 2008. Displacement of Japanese native bumblebees by the recently introduced *Bombus terrestris* (L.) (Hymenoptera: Apidae). Journal of Insect Conservation, 12, 135–146.

Kraus F.B., Szentgyorgyi H., Rozej E., Rhode M., Moron D., Woyciechowski M., Moritz R.F.A., 2011. Greenhouse bumblebees (*Bombus terrestris*) spread their genes into the wild. Conservation Genetics, 12, 187–192.

MacFarlane R.P.,Gurr L., 1995. Distribution of bumblebees in New Zealand. New Zealand Entomologist, 18, 29–36.

Morandin L.A., Laverty T.M., Kevan P.G., 2001. Bumblebee (Hymenoptera: Apidae) activity and pollination levels in commercial tomato greenhouses. Journal of Economic Entomology, 94(2), 462–467.

Rasmont P., Coppee A., Michez D., de Meulemeester T., 2008. An overview of the *Bombus terrestris* (L.1758) subspecies (Hymenoptera: Apidae). Annals de la Societe Entomologique de France, 44, 243–250.

Ruz L., Herrera R., 2001. Preliminary observations on foraging activities of *Bombus dahlbomii* and *Bombus terrestris* (Hym: Apidae) on native and non-native vegetation in Chile. ActaHorticulturae, 561, 165–169.

Sladen F.W.L., 1912. The humble-bee, MacMillan, London

van der Velden N.J.A., Suay R., Urbaneja A., Giorgini M., Ruocco M., Poncet C., Lefevre A., 2012. Recent developments and market opportunities for IPM in greenhouse tomatoes in southern Europe; Consequences for advanced IPM toolboxes and greenhouse engineering. Research report, LEI Memorandum 12-077, 41p.

Velthuis H.H.W., van Doorn A., 2006. A century of advances in bumblebee domestication and the economic and environmental aspects of its comercialization for pollination. Apidologie, 37, 421-451.

Williams P.H., 1998. An annotated checklist of bumblebees with an analysis of patterns of description. Bulletin of Natural History Museum, Entomology Series, 67, 79–152.

Yilmaz I., Ozkan B., Gurel F., Karaman S., 2002. The use of bumblebee in greenhouse vegetable production and bumblebee marketing in Turkey. Tanta University Journal of Agricultural Research, 28(3), 524–534.

Copyright of Scientific Papers: Series D, Animal Science - The International Session of Scientific Communications of the Faculty of Animal Science is the property of University of Agricultural Sciences & Veterinary Medicine, Faculty of Animal Science and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.